ART. XVII.—*Analysis and Specimens of a Persian Work on Mathematics and Astronomy, by the late* JOHN TYTLER, Esq.

Read June 4th, 1836.

A SHORT time before my leaving Calcutta, a Maulavi, by name Gholaum Hosain, was introduced to me under the character of a great mathematician and astronomer. I found he was in the service of Mirza Khán Bahádur, the Mohammedan son of Mitrajít Singh, the well-known Mahá Rájá, of Takari, in Bahar. The Maulavi stated, that he had devoted himself to the study of mathematics and astronomy, not only as far as they are contained in the Arabian and Brahminical writings, but also as far as he could gain from the interpretation of European books, as given him by European friends, he himself being ignorant of English; that he had, under the patronage of Khán Bahádur, compiled a system of these sciences from all these sources, and that his patron had supplied him with a sum of money to publish this book at one of the lithographic presses of Calcutta. This was the purport of his present errand down the country, and he had already got about 100 pages carried through the press. His object in applying to me was to obtain a recommendation of his work to the Government Education Committee. He produced his MS., but it was much too long to examine minutely in the short time I had to remain in Calcutta, and in my then harassed state of mind and body. I saw enough, however, to convince me that it was a work of very considerable merit and information, compared with the author's opportunities. It commenced with the elements of geometry and arithmetic as known to the Hindús, and thence went on. In the course of the work are explained, the European methods of decimal fractions, logarithms, and trigonometrical tables. The author then gives a system of astronomy, first according to the Brahmins, then according to Ptolemy, and then according to Copernicus, together with an account of astronomical instruments, and the mode of calculating astronomical tables and almanacs. The whole MS., as will appear from the author's own computation, comprehends 900 closely-written quarto pages. To be able to recommend the work with greater confidence to the Government Committee, I requested the author to furnish me with a few short extracts, and as my hasty departure from Calcutta precluded my taking any steps in the matter there, I translated the extracts during

my passage to the Cape of Good Hope, and transmitted them from thence to the Committee in Calcutta, wi'.. a letter explanatory of the nature of the work and the views ot ..ne author. I have not as yet heard anything of the result. As the extracts were sent me in duplicate, I trust it may not be unsatisfactory to the Society to receive the other copy, together with a translation. They are as follows:

No. I. is a letter from the author to me explanatory of his views.

No. I.

" To the gentleman of lofty virtues, of sublime dignity, the bestower of bour y, the goal of hope to the miserable, perpetua sit beneficentia ejus.

" After preferring what is required of reverential salutation and honour, let it be proved to your sun-like heart, that the elements of mathematics, especially geometry and arithmetic, are full of real amusement, and that in them there is no uncertainty as in other sciences, besides which, manifold an multiplied advantages are prepared for their students. Hence, this humble one, contrary (to the practice of) his equals, has spent much time in acquiring this science, and has derived great benefit from the study under masters of the works of the ancients, which exist in the Arabic and Persian languages, and he has acquired (the knowledge of) many valuable particulars which are not to be found in the writings of the Greeks, by the opportunity of associating with (European) gentlemen of lofty dignity. After these acquisitions it was continually in my humble heart that I should compose a comprehensive book, which should be extracted from the aforesaid books, with many additional observations in the Persian language, that the generality of the inhabitants of India, who pay little attention to this science, should be benefited; but, on account of the continual occurrence of worldly affairs, which is unavoidable to every individual of the human race, my leisure did not allow me to turn myself to this quarter; at last, by a favourable accident, a short time ago, Rájá Khán Bahádur Khán Diláwar Jang, who is an admirer of profound sciences, became my surety and confederate in the times of composition; on this account your humble servant, with his whole heart, composed a book comprising the general principles of mathematics in such a manner that it might render the books of the ancients unnecessary to students, and, in short, the nature of its composition will be manifest to your noble understanding from the list of contents

enclosed in this petition; and that the existence of this book may continue for some time, I have caused the printing of it to be commenced at the lithographic press, and I am myself employed in correcting it, so that the book itself should be suited to practical purposes; but the desire of (me a) seeker of fortune, is this, that, since your worship is the touchstone of the standard of science, you should take the book under your noble inspection, in such a manner, that, by the determination of your happy judgment, this book should be useful to the public, you should in the way of benevolence be pleased so to bestow your endeavours, that the gentlemen of lofty dignity of the Committee, perpetua sit prosperitas eorum, (the universal benevolence of which most liberal personages is always employed in the business of diffusing knowledge, and the intelligence of the wise, and the universal tranquillization of the creation,) should direct particular attention to be paid to the printing of this book, as this will not be far off from the encouragement of talent. Further, may the days of cheerfulness and pleasure be perpetual, accompanied by a state of affluence.

"The supplicatory petition of the sinner Gholaum Hosain, of Juanpore. Written on the 12th November, 1834."

No. II. is a list of the contents of the work, divided into its several books and chapters.

No. II.

"Contents of the book entitled, the Bahádur Khánian Collection, which comprises the sciences of the elements of mathematics, and consists of about 900 pages of one pattern, divided into six treasuries, ut enumeratum est.

"Treasury the first. Of the science of Arithmetic, comprising 274 propositions arranged into six castles.

"1. An account of the definitions, object, and principles of geometry.

"2. The principles of straight lines, angles, and rectilinear surfaces, comprised in 49 propositions.

"3. The principles of circles and arcs, the properties of lines and angles, which are produced by the comparison of circles, 35 propositions.

"4. The principles of general quantities, and the rules of simple and compound and derivative proportion, 68 propositions.

"5. The principles of solids, cylinders, pyramids, cones, and spheres, 61 propositions.

"6. The principles of circles and arcs, and angles, which exist in the surface of a sphere and of ovals, 61 propositions.

"Treasury the second. Of Optics, which consists of 59 propositions, arranged in three castles.

"1. Of the principles of vision.

"2. Of the science of optics, comprising 45 propositions.

"3. Of the science of reflection, comprising 14 propositions.

"Treasury third. Of Arithmetic, comprising an introduction, and eight treasuries.

"Introduction. Of the definition of arithmetic, and an explanation of its object.

"1. Of the operations of the arithmetic of integers.

"2. Of the operations of the arithmetic of fractions.

"3. Of the operations of the arithmetic of decimal fractions, and the rules of logarithms, and a table of them.

"4. Of the operations of arithmetic by sexagesimal figures.

"5. Of the higher rules.

"6. Of discovering unknown quantities by means of the rule of false.

"7. Of the operations of algebra for the practice and exercise of students.

"8. Of miscellaneous questions for the practice and exercise of students.

"Treasury the fourth. Of extracts from the sciences of the three preceding treasuries; that is, of mensuration, of finding the magnitudes of sines and tangents, the division of circles, and their parts, comprising one introduction and seven chapters.

"1. Of finding the magnitude of chords and sines, and of their tables.

"2. Of finding the magnitudes of tangents, and of their tables.

"3. Of the division of circles.

"4. Of knowing the magnitudes of the sides and angles of triangles.

"5. Of knowing the quantities of the sides and angles of spherical triangles which exist on the surface of a sphere.

"6. Of the sequelæ to the measurement of the surface of the earth, and the knowledge of the height of elevations, and the breadth of rivers, and the depth of wells.

"Treasury fifth. Of the science of Astronomy, comprising one key, five castles, and a conclusion.

" Key of the definition, and object, and origin of the science of astronomy.

" 1. A general account of the sciences of the spheres, and the inferior elements, and the nature of the stratification of these bodies, and the inferences.

" 2. An account of instruments for observing, the method of observation, and a knowledge of spherical quantities.

" 3. Of the particular form of the spheres, and an account of the nature and quantities of their motion, according to the rules of observation, and the finding of mean and equable (motion).

" 4. Of the form of the earth and the particularities of its elevation, and of things connected therewith.

" 5. Of the knowledge of distances and magnitudes.

" Conclusion. An explanation of the differences which exist among the observations of astronomers.

" Treasury the sixth. The explanation of the construction of astronomical tables and almanacs, comprised in two castles.

" 1. An explanation of the foundation and elements of astronomical tables.

" 2. An explanation of the technical terms of an almanac."

The next is the method of determining the proportion between the diameter of the circle and its circumference. I requested the author more particularly to give me these as a proof of how far he had proceeded in advance of his countrymen. All the other Mohammedan mathematicians, whom I had ever seen, contented themselves with the coarse approximation of 7 to 22, but it will here be seen that the author carries it on to seven places of decimals. To understand his calculation it is necessary to premise, that the Mohammedans, in writing trigonometrical, astronomical, and all other calculations, in which we use decimal fractions, employ the sexagesimal system of the Greeks, that is, the system in which degrees are reckoned as integers; minutes, as figures immediately on the right hand of the decimal point; seconds, as the second figure on the right hand; thirds, as the third, &c.; and these they express by the well-known ابجد *Abjud* letters. This system, however different in appearance, is founded on the same principles as our decimal notation, with two great advantages: First, that its base being 60 instead of ten, all numerical expressions are abbreviated; and, secondly, that 60 having so many more divisors than ten, the number of infi-

nite decimals is diminished. Its only fault is the want of a simple set of characters up to 59; were they invented, the sexagesimal system would be greatly preferable to the decimal.

I take as an example the first number occurring in the extract, the chord of A B, which, in the Arabic characters is ا ب مط ند ل خامسه that is, 1′, 2″, 49‴, 54^{iv}, 30^{v}, or, to use the letters corresponding to the abjud among the Greek astronomers, it is, $\alpha.\beta.\mu\theta.\nu\delta.\lambda$ fifths, that is, $\frac{1}{60}+\frac{2}{60^2}+\frac{49}{60^3}+\frac{54}{60^4}+\frac{30}{60^5}$, all which, added together, will be found nearly equal to our decimal, .01694575, &c.; that is, $\frac{0}{10}+\frac{1}{10^2}+\frac{6}{10^3}+\frac{9}{10^4}+\frac{4}{10^5}+\frac{5}{10^6}+\frac{7}{10^7}+\frac{5}{10^8}$ &c.

It is also to be observed, that the Arabs reckon the radius of the circle to be equal to the base of the sexagesimal system, that is, to 60; hence, in comparing their tables with ours, their numbers must always be divided by 60. Now, dividing the above number, there will be found $\frac{.01694575}{60} = .000282429$, &c. for the chord or line of one minute, the chord and sine of very small arcs being identical; and, in our tables, the sine of 1′, is .0002909, agreeing with the above very nearly.

Again, the last number in the extract from the author's tables, is the tangent of 2° 59′, which is said to be ج* ز لز ء لز رابعه or in Greek letters $\gamma.\ \zeta.\ \lambda\zeta.\ \delta.\ \lambda\zeta.$ fourths, that is, 3° 7′ 37″ 4‴ 37^{iv} $= 3+\frac{7}{60^1}+\frac{37}{60^2}+\frac{4}{60^3}+\frac{37}{60^4} = 3.1269658177$, &c., and this divided by $60 = .05211609696$ for the natural tangent of 2° 59′ decimally. In our tables it is .0521161, which is very near.

According to this system integers are called degrees, درجات *durját*. Numbers in the second place, which correspond to our tens, are called مرفوع مرة *Marfúa Marratan*, (once elevated, or elevation). Numbers in the third place, our hundreds, are *musáni*, مثانى (duplication). In the fourth place, or thousands, are, *musális*, مثالث (Triplication), &c. So that, one elevation $=60$; one duplication $= 60^2 = 3600$; one triplication $= 60^3 = 216000$, &c.

In the same manner we might call 10 an elevation; 100, or 10^2, a duplication; 10^3, or 1000, a triplication, &c.

* In the Abjud letters ج (Jim) is written thus (ج) also د (Dal) is written like Hamza (ء) and ز (ze) has its diacritical point omitted.

Hence, the number given in this extract,

نط نط نط نط مج لج ب کر مر کب کو یه that is

$\nu\theta.\ \nu\theta.\ \nu\theta.\ \nu\theta.\ \mu\gamma.\ \lambda\gamma.\ \beta.\ \kappa\zeta.\ \mu\zeta.\ \kappa\beta.\ \kappa\varsigma.\ \iota\epsilon$

which I have decimalized thus :—

Elev. Deg.

$59\ 59\ 59'\ 59''\ 43'''\ 33^{iv}\ 2^{v}\ 27^{vi}\ 47^{vii}\ 22^{viii}\ 26^{ix}\ 15^{x}$, is, in reality $59 \times 60 + 59 + \frac{59}{60} + \frac{59}{60^2} + \frac{43}{60^3} + \frac{33}{60^4} + \frac{2}{60^5} + \frac{27}{60^6} + \frac{47}{60^7} + \frac{22}{60^8} + \frac{26}{60^9} + \frac{15}{60^{10}}$ and so of others.

In the same manner the distance between the two foci of the earth's orbit is stated to be $\beta.\ *.\ \lambda\zeta.\ \kappa\delta$ thirds, or $2^\circ\ 0'\ 37''\ 24'''$, the half of which, or $1^\circ\ 0'\ 18''\ 42'''$, that is, $1 + \frac{0}{60} + \frac{18}{60^2} + \frac{42}{60^3}$ is the excentricity, the semi-major axis being 60.

$$
\begin{aligned}
\text{That is,}\quad 1 &= 1.000000000 \\
\frac{0}{60} &= 0.000000000 \\
\frac{18}{60^2} &= 0.000513888 \\
\frac{42}{60^3} &= 0.000055555 \\
& \overline{60)\,1.000569444} \\
& \overline{\quad 0.016676157}
\end{aligned}
$$

In Vince's astronomy, Vol. I., p. 141, it is stated to be from .01681395 to .016919, which agrees nearly.

III.

Extract from the book called the Jámia Bahádur Khání, (the Bahádur Khánian collection,) as a specimen.

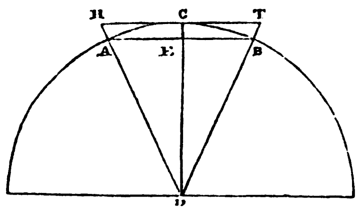
" Castle third, of the division of the circle ; and the meaning of that is, to know the arithmetical proportion of the diameter to its circumference, which is the nearest to the real proportion of the quantities, and for this we must suppose an arc A B, a very small part of the circumference ; for example, one minute, and in this case the magnitude of the chord A B, is $\alpha.\ \beta.\ \mu\theta.\ \nu\delta.\ \lambda$ fifths, ($1'\ 2''\ 49'''\ 54^{iv}\ 30^{v}$,) and the centre of the circle is the point D ; join D A, D B two radii, and draw from the centre D a perpendicular D E to A B, and by proposition γ (3) of 3, treasury first ; this perpendicular will bisect the said chord in the point E. Produce

this perpendicular on the side of E to the point G, which is in the circumference, and draw from the point G the perpendicular H G T on D G till it meets D A, D B, produced in the points H, T. Then, I say, that when the known square of A E, which is, $\iota\varsigma$. $\kappa\varsigma$. $\nu\zeta$. $\lambda\beta$. $\iota\beta$. $\lambda\zeta$. $\lambda\gamma$. $\mu\epsilon$. tenths ($16'''$ 26^{iv} 57^{v} 32^{vi} 12^{vii} 37^{viii} 33^{ix} 45^{x}) is subtracted from the square of D A the semidiameter, there remains

Elev.

$\nu\theta$. $\nu\theta$. $\nu\theta$. $\nu\theta$. $\mu\gamma$. $\lambda\gamma$. β. $\kappa\zeta$. $\mu\zeta$. $\kappa\beta$. $\kappa\varsigma$. $\iota\epsilon$. tenths, (59. 59° $59'$ $59''$ $43'''$ 33^{iv} 2^{v} 27^{vi} 47^{vii} 22^{viii} 26^{ix} 15^{x}) which begins from elevation and ends with tenths, and this is the square of D E.

Fig. 1.



"Its root which is $\nu\theta$. $\nu\theta$. $\nu\theta$. $\nu\theta$. $\nu\alpha$. $\mu\varsigma$. fifths, (59° $59'$ $59''$ $59'''$ 51^{iv} 46^{v}) is the length of D E; and by the similarity of the two triangles D E A, D G H, the proportion of the known side D E to the side D G the semidiameter, is as the proportion of the known side A E to the unknown side G H; hence if we divide A E by D E properly reduced, there will come out G H, and that is $\lambda\alpha$. $\kappa\delta$. $\nu\zeta$. $\iota\epsilon$. δ fifths ($31'$ $24''$ $57'''$ 15^{iv} 4^{v}) and the double of this which is α. β. $\mu\theta$. $\nu\delta$. λ.η fifths (1° $2'$ $49''$ $54'''$ 30^{iv} 8^{v}) is the length of H T; and since A B is the chord of one minute there is no doubt that it is the side of an equilateral and equiangular figure described in the circle, the number of whose sides is $\kappa\alpha$. $\underset{\cdot}{\alpha}$. χ ($21 \times 1000 + 600$) that is twenty-one thousand six hundred, (the number of minutes in the whole circumference) which in reality is six duplications (6×60^{2}); so if we multiply A B by six duplications it will be the length of all the said sides $\tau o\varsigma$. $\nu\theta$. $\kappa\zeta$ seconds; that is, three hundred and seventy-six degrees, fifty-nine minutes, and twenty-seven seconds, in parts of the diameter which is $\rho\kappa$ (120) degrees; and by proposition ν (50) of 4, treasury first, the circumference of the circle is greater than this quantity. Again, H T is the side of the same figure which is described about the circle, and if we multiply H T into the same six duplications, the length of all the sides of the

figure about the circle will be obtained $\tau o\varsigma.\ \nu\theta.\ \kappa\zeta.\ *.\ \mu\eta$ fourths, that is, three hundred and seventy-six degrees, fifty-nine minutes, twenty-seven seconds, no thirds, and forty-eight fourths; and by proposition $\nu\alpha$. (51), the circumference of the circle is smaller than this; hence the circumference of the circle is as it were the mean number of these two, so that if we take half the difference which is $\kappa\delta$ fourths, (24^{iv}, that is $\frac{24}{60^4}$), and either add it to the said smaller number, or extract it from the greater; in both cases the amount of the circumference of the circle is found $\tau o\varsigma.\ \nu\theta.\ \kappa\zeta.\ *.\ \kappa\delta$ fourths, and if we reduce the degrees to elevations, the form of the expression will be this $\varsigma.\ \iota\varsigma.\ \nu\theta.\ \kappa\zeta.\ *.\ \kappa\delta$, that is, six elevations, sixteen degrees, fifty-nine minutes, twenty-seven seconds, no third, and twenty-four fourths; after that I divide the quantity of the circumference by the diameter, which is two elevations, there comes out $\gamma.\ \eta.\ \kappa\theta.\ \mu\gamma.\ \lambda.\ \iota\beta$. fifths, ($3^\circ\ 8'\ 29''\ 43'''\ 30^{iv}\ 12^{v}$.)

"Hence the proportion of the diameter to the circumference is the same as the proportion of unity to this number; that is, to three integers, and the remaining sexagesimal fractions, and if we reduce each antecedent and consequent to a common *consequent* of fifths, we shall obtain the proportion of the diameter to the circumference in decimal figures, as 777600000 to 2442900612. And as the common measure of these two numbers is twelve, so, for abbreviation, we divide each antecedent and consequent by twelve. Then the twelfth part of the antecedent is 64800000, and the twelfth part of the consequent is 203575051, and then by a minute consideration, these two numbers are the least integral numbers, whose proportion is as the proportion of the diameter and the circumference. And again, when we divide the first number by the second, by the calculation of decimal fractions, it produces the number 3.1415903; that is, three integers and fourteen lacks, and fifteen thousand and nine hundred and three parts of one crore; hence the circumference of every circle whose diameter is supposed to be unity is three times and the amount of this fraction.

"Admonition. That which is common among surveyors is, that the proportion of the diameter to the circumference is as the proportion of 7 to 22. This proportion is less than the accurate proportion which has been stated, for if we reduce the proportion of 7 to 22 to decimal fractions, it is as the proportion of unity to this number 3.1428571, and this is greater than the first by this fraction, .00012668; but as this excess is approximately one part out of a

thousand parts, so in the measurement of small circles the difference is not perceptible, and hence this is the proportion generally employed.

"Inference. As the circumference of the circle in parts of the diameter is $\tau o \varsigma.\ \nu\theta.\ \kappa\zeta.\ *.\ \kappa\delta$ fourths—if this be divided by 360, which is the number of the circumferential degrees, the quotient which is $\alpha.\ \beta.\ \mu\theta.\ \nu\delta.\ \lambda.\ \delta$ fifths i the quantity of one circumferential degree in parts of the diameter, and if we divide one circumferential degree by this number, the quotie , which is $*.\ \nu\zeta.\ \nu\zeta.\ \mu\delta.\ \nu\zeta.\ \mu$ fifths (0°. 57′ 57″ 44‴ 57^{iv} 40^{v}) is the quantity of one diametrical degree in parts of the circumference."

The next extract will be read with some interest. It is an explanation of Seth Ward's famous problem for determining the place of a planet by supposing its motion round the focus in which the central body is *not*, as equable. The method in which this is treated is remarkable. The author begins by attributing the discovery of the ellipticity of the planetary orbits to one of his own countrymen. This is not perhaps very wonderful, considering his situation and birth-place. He then goes on to endeavour to reconcile this to the Ptolemaic idea of circular orbits, and this he does by a very fanciful hypothesis of a circle and epicycle: then taking it for granted that the motion of the planet round the empty focus is uniform, he shows the method of finding the planet's true place, and concludes with some observations. The question that naturally occurs on this occasion is, how the knowledge of this problem could have travelled to the court of the Great Mogul. Calculating from the probable ages of the authorities which the author quotes, it must have been known in the East for a hundred years. It was published in Europe (see Vince's Astronomy, Vol. I., chap x.) in 1654, and perhaps may have reached Delhi about the middle of the last century. It would be desirable to investigate the channel through which it did so, as a matter of rational curiosity, and also as affording useful hints as to the best method of diffusing European science among the Oriental nations.

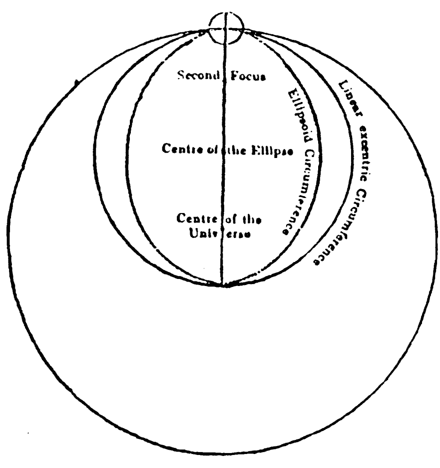
IV.

From the book entitled the Baháu Khánian collection.

"The majority of ancient and most of modern observers have determined the orbit to be an excentric circle, and have calculated the

partial equation on this supposition; and Mirza Khair Allah, the arithmetician, in his commentary on the tables of Mohammed Shah, has asserted that he has found, not only that the orbit of the sun is excentric, but that the orbits of all the signs are of an elliptical form; by this proof, that if we reckon the place of the sun and planets, according to the equation of a circle, we shall not find them agreeable to observation; contrary to what takes place in the equation which is produced in the case of the ellipse, and if we determine the place from that *latter* calculation, the determination will be more agreeable to observation. Hence the rule of conversion proves that the orbits are elliptical, and for astronomical purposes the following explanation is given; that this supposition is realized by supposing the existence of three spheres, one agreeable, the other excentric, so

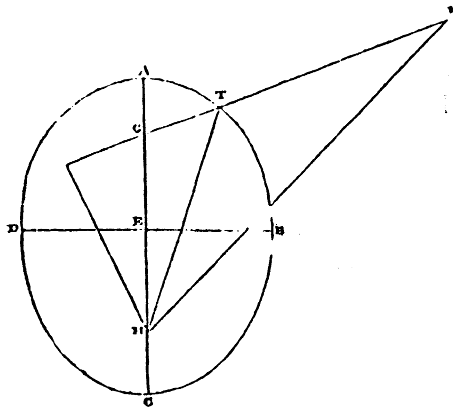
Fig. 2.



that the distance between the two centres should be equal to half the distance between the known centres, and on the circumference of the excentric *sphere*, an epicycle whose semidiameter is equal to half the difference of the two diameters, the longer and shorter of the ellipse, that is in the figure of the solid sphere, the semidiameter of the epicycle is equal to the sum of this difference, and the semidiameter of the sun, and the superior movement of the epicycle, is to be in the same direction as that of the excentric sphere, and of double the angular velocity, and in the beginning of things the centre of the epicycle must have been at the greatest distance of the excentric sphere, and the centre of the sun at the greatest distance of the epicycle. In this case, by the motion of the epicycle and the excen-

tric sphere, the centre of the sun will describe an orbit, similar to an elliptic orbit; and the centre of the universe will be one of the two focal points of the ellipse, and the centre of the excentric sphere will fall in the place of the centre of the ellipse, and the other focal point, towards the other side of the excentric sphere, in the direction of the apogee, at the same distance as is between the centre of the universe and the centre of the excentric sphere; and the distance between the two focal points is called the sine of the extreme equation, and the second focal point is supposed to be the known place of the excentricity; so that the epicycle should be carried out of the middle; and all that has been said will be evident from this figure. The compiler says, that this demonstration will not prove the orbit to be *exactly* elliptical, but only that, from the small space between the two focal points, it is very similar to an ellipse, and the equation which is produced on the supposition of an ellipse, is not perceptibly different. At present it is incumbent on us to explain the mode of demonstrating the method of finding the equation in an elliptical orbit; and we say, let A B C D be an elliptical orbit, A C is its

Fig. 3.



long, and B E D its short axis, intersecting at right angles; H the centre of the universe, which is one of the two focal points; G, the place of the excentricity, which is the second focal point; A is the sun's point of apogee; C the point of perigee, and we suppose T, in the circumference of the ellipse, to be the centre of the sun, and we join G T, H T, and then the angle A G T, which is the measure of the motion of the sun's centre from the point A, is known, and so the angle T G H, which is the complement of the angle A G T to

the half circumference, is also known, and the two sides G T, H T, though they be not known separately, yet their sum which is equal to A C, the long axis of the ellipse, that is $\rho\kappa$ (120) degrees is known, and we produce G T towards I, till G I be equal to the long axis; in this case T I is necessarily equal to T H, then we join I H, so that the isosceles triangle H T I be produced; and we show that in the triangle H G I two sides, H G, G I, and the angle H G I are known, hence the remaining sides and angles will be known, that is, the side I H, and the two angles G H I, G I H are known, and since the two angles T H I, T I H, on account of the equality of T I, T H are equal to the exterior angle G T H of the triangle H G T, which is, the angle of the equation is known to be double of the angle T I H, and that is what was required.

The construction is, that from the point H to I G, the perpendicular H K is to be drawn, and since in the right-angled triangle H K G the side G H is known, that is, it is β. *. $\lambda\zeta$. $\kappa\delta$. thirds (2° 0′ 37″ 24‴), and the angle A G T for example, is ξ (60) degrees, so the angle K G H which is opposite is also ξ (60) degrees, and the angle at K is right, hence the angle G H K is λ (30) degrees; hence if G H be reduced and multiplied into the sine of H G K, which is $\nu\alpha$. $\nu\zeta$. $\mu\alpha$ seconds (51° 57′ 41″) the product which is α. $\mu\delta$. $\kappa\zeta$. $\kappa\epsilon$ thirds (1° 44′ 27″ 25‴) will be the amount of H K, and this, if it be reduced and multiplied into the sine of the angle G H K, which is λ. * * * degrees (30°), the product which is α. *. $\iota\eta$. $\mu\beta$ thirds (1° 0′ 18″ 42‴) is the length of the side G K. Now in the right angled triangle I K H, the side I K is $\rho\kappa\alpha$· *· $\iota\eta$· $\mu\beta$ thirds (121° 0′ 18″ 42‴), and the square of that is δ· δ· β· $\iota\varsigma$· $\lambda\eta$· ς· α fourths (4. 4. 2° 16′ 38″ 6‴ 1^{iv}) and the square of H K is γ. α. $\iota\alpha$. $\iota\epsilon$. $\iota\beta$ fourths (3° 1′ 11″ 15‴ 12^{iv}), and the sum of the two squares is

dplus. Elev.

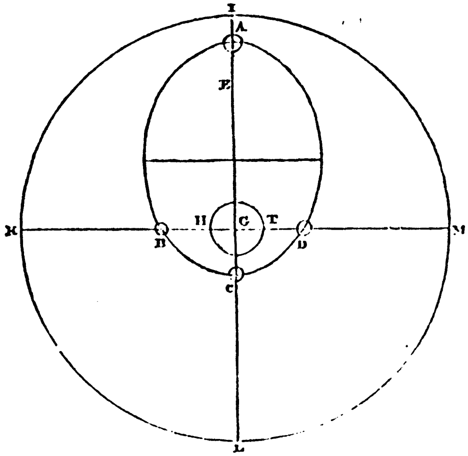
δ. δ. ϵ. $\iota\zeta$. $\mu\theta$. $\iota\eta$. $\iota\gamma$ fourths (4. 4. 5° 17′ 49″ 18‴ 13^{iv}). The root of that which is $\rho\kappa\alpha$. α. α. γ thirds (121° 1′ 1″ 3‴) is the length of the side I H. After this I reduce and divide H K by H I, there

Elev.

comes out *. $\nu\alpha$. $\mu\zeta$. $\kappa\beta$ seconds (0. 51° 47′ 22″), the sine of the angle I, and the arc of this (as found) in the table of sines, is the magnitude of the angle of the equation G T H, α. $\lambda\eta$. $\nu\delta$ seconds (1° 38′ 54″). And observe that the extreme excess of the annual equations of the point of the greatest and least distance, is *. α. $\nu\eta$ seconds (0°. 1′ 58 .) If this difference be added to the mean daily (motion) of the sun, the sum, which is α. α. ς. κ thirds (1° 1′ 6″ 20‴)

is the greatest daily velocity of the sun, and if it be subtracted from the mean daily motion, the remainder, which is *. νζ. ι. κ thirds (0° $57'$ $10''$ $20'''$) is the least daily velocity Observation.—European philosophers consider the earth as moving in an elliptical orbit, and the sun as fixed in the longer diameter of the ellipse, so that the centre of the sun coincides with one of the two focal points, and the centre of the ecliptic is the centre of the sun. For example, A B C D

Fig. 4.



is the elliptic orbit of the motion of the earth, and A C is the longer diameter, and the two focal points on the longer axis are E and G, and H T is the sun's disk, and I K L M is the ecliptic. Then after determining these lines, I say that if the earth passes over the point C, it is at its least distance from the sun; and with respect to the ecliptic, it is in the point L, and it is supposed that the place of the sun is in the point I, which is its higher apsis, and is opposite to the point L, and thus the position of the earth in every point being known, the position of the sun is to be considered as opposite to that; and if the earth proceeds from the point C towards D, it is supposed that the sun proceeds from I towards K, and the distance of the earth from the sun increases daily, till it comes to the point A, and then the earth will have come to its greatest distance from the sun, and the sun is seen in the point L, and this point L is imagined to be the higher apsis of the sun, and the distance of its passage from the point A is the decremental distance, and when it reaches C, then it appears in its original state; and as B C D is less than half of the elliptic orbit, and the part corresponding to it in the ecliptic is a semicircle, so an inhabitant of the earth passes over this

half quickly, and hence he supposes that the sun passes through the half M I K quickly, and for the same reason the earth passes over the half K I M slowly. And as it is certain that from the earth the situation of the sun appears opposite to that of the earth, so if (the spectator) be supposed looking at the centre of the sun, the place of the earth will appear opposite to the sun, that is in that half in which the motion of the sun appears slow, the earth will appear to go quick, and in the quick half, slow; hence if the equation which has been found by the demonstration with reference to the focal point be brought into operation reversedly, on the supposition of the earth's motion, and the place of the earth be determined, what is required will be found. And it is sufficient for us, if after determining the sun's place we should add or subtract half a revolution to or from it, so that according to the phraseology of Europeans, we may obtain the earth's place.

The next extract does not properly belong to the book in question. Its history is this—On Gholaum Hosain's arrival in Calcutta, he paid a visit to the Madrasah, or Mohammedan College there, and had a conference with the students on the subjects of their studies. The result was, that as a trial of skill he proposed a number of problems for them to resolve, and they in return proposed one to him. Of all these he gave me a copy. Those proposed by him to the students are as follows:

I. Produce a finite straight line, so that its square shall be equal to the rectangle between the whole line so produced, and the part produced.

II. Within a circle describe another circle touching the first, and cutting out of it a given part.

III. Describe a circle equal to a given number of other circles.

IV. Determine the length of the perpendicular from the apex of a given scalene triangle to the base.

V. Prove that the area of an equilateral triangle is equal to the square root of thrice the square of the fourth part of the square of the side.

VI. If a line be drawn from one extremity of the diameter of a circle, to a tangent raised from the other extremity, the rectangle contained by the whole line thus drawn, and the part of it within the circle, is equal to the square of the diameter.

VII. Is the proposition whose translation is given in this extract.

VIII. From the cube of a given number to find the cube of the next number above and below it in the natural series.

IX. Having given the value of $x^2 z$ and $x z^2$ to find x and z.

The question which the students proposed to him was this. Let the base of the right-angled triangle be 60. From the extremity of its perpendicular, let a line be drawn to the base, dividing it into segments of 45 and 15, and forming with the hypothenuse an angle of ten degrees, to determine the length of the perpendicular.

V. Problem Seventh.

The method of finding the quantity of the angles produced at the elliptic circumference, by joining the lines between the two focal points and the point of the circumference, and these are called the angles of the equation, and this serves to find the places of the planets according to the system of those who consider the orbit of the ecliptic to be elliptical. For let A B C D, (Fig. 3) be the elliptical orbit, and A C the longest, and B E D the shortest diameter intersecting in E at right angles, and G H the focal points, and the angle of equation required to be found G T H, and T, the place of the centre of the planet moving round the centre G, in a mean equable motion, and H the place of the spectator; and the line G H between the two centres, which in the language of astronomers is called the line of the extreme equation, is known by observation, and the angle A G T is the angle of the motion of the centre of the planet, and that is also known at all times by the mean tabular (calculations), and the angle T G H, which is the complement of the known angle A G T to two right angles, is itself known. Now let us produce G T to I, so that G I should be equal to A C, the longest diameter, whose length is ρκ (120) degrees; and since T H, added to T G is also equal to A C, so after taking away the common part T G, there remain the equal parts T I, T H. Now let us produce T G to K, and raise on it H K, a perpendicular from the point H, and in the right-angled triangle G K H, the angle K G H which is equal to the known angle A G T is also known (Eucl. i. 15), and thus the angle K H G, the complement of the angle K G H to a right angle is known, and its side G H is known. Now the philosopher of Tús (Nassar al Din) has proved in his book called Kashf-al-Kinau (Denudatio Calanticæ), and also at the end of the twelfth chapter of the first book of the Almagest, that the proportion of the sides of a triangle, is the same as that of the sines of the opposite angles, and hence if G H be multiplied into the sine of the angle H G K, reduced, there will be found the magnitude of H K; and if

this be similarly multiplied into the sine of the angle K H G, there will be found the magnitude of G K. Now we say, in the right-angled triangle I K H, the side I K is known because it is the sum of I G, G K which are known, and K H is known; and (Eucl. i. 47) I H is the root of the sum of the squares of I K and K H, and is known; hence if the side H K be divided by the side I H reduced, the quotient is the sine of the angle at I, the arc of which is the magnitude of the angle at I, and double of it (Eucl. i. 5, and i. 32) is the magnitude of the angle H T K required, and that is what was proposed.

The last extract (Fig. 5.) is a specimen of the Arabic astronomical tables. The notation of these, it will be seen, is the sexagesimal Ptolemaic system, as has been explained in observations on extract III.

These extracts will be sufficient to give a general idea of the nature of this book, and of the extent of the author's knowledge, and I think it will be allowed that he well deserves the patronage, not only of the British Indian Government, but even of such societies in this country as take an interest in the literary efforts of the East. Unfortunately a great prejudice has for some time existed against such works, not from their contents, but from the circumstance of their being written in Persian, a language which it is now considered desirable to suppress or exterminate. Of the policy of the measures which have been taken for this purpose, or the chance of their ultimate success, I shall not pretend to give an opinion, and I have alluded to the subject only to express a hope, that notwithstanding the unfavourable state of public opinion, the recommendation which I took the liberty of making to the Government Committee of Calcutta, may have been attended with some benefit to Maulavi Gholaum Hosain.

JOHN TYTLER.

14, *Avenue Road, Regent's Park,*
April 16, 1836.

FIG. V.

A TABLE OF PRIME TANGENTS, WHICH ARE ALSO CALLED VERSED TANGENTS.

Deg.	*		α		β	
Min.	Tangent.	Difference.	Tangent.	Difference.	Tangent.	Difference.
	Deg. Frths.	Min. Frths	Deg. Frths.	Min. Frths.	Deg. Frths.	Min. Frths.
*	* * * * *	α.β.μθ.νε	α.β.ν. ιζ.λη	α.β.να.ε	β.ε.μβ.νγ.ι	α.β.νδ.λγ
α	α.β.μθ.νε	νδ	γ.νγ η.μγ	ζ	ϛ.με.μζ.μγ	λζ
β	β.ε.λθ.μθ	νε	δ.νε.νθ.ν	ι	ζ.μη.μβ.κ	μβ
γ	γ.η.κθ.μδ	νε	ε.νη.να.*	ιβ	η.να.λζ.β	μζ
δ	δ.ια.ιθ.λθ	νε	ζ.α.μβ.ιβ	ιδ	θ.νδ.λα.μθ	νβ
ε	ε.ιδ.θ.λδ	νε	η.δ.λγ.κϛ	ιζ	ι.νζ.κϛ.μα	νζ
ϛ	ϛ.ιϛ.νθ.κθ	νϛ	θ.ζ.κδ.μγ	κ	ιβ.*.κα.λη	νε.α
ζ	ζ.ιθ.μθ.κε	νϛ	ι.ι.ιϛ.γ	κβ	ιγ.γ.ιϛ.λθ	ϛ
η	η.κβ.λθ.κα	νϛ	ια.ιγ.ζ.κε	κδ	ιδ.ϛ.ια.με	ια
θ	θ.κε.κθ.ιζ	νϛ	ιβ.ιε.νη.μθ	κζ	ιε.θ.ϛ.νϛ	ιϛ
ι	ι.κη ιθ.ιγ	νζ	ιγ.ιη.ν.ιϛ	λ	ιϛ.ιβ.β.ιβ	κα
ια	ια.λα.θ.ι	νζ	ιδ.κα.μα.μϛ	λβ	ιζ.ιδ ιζ.λη	κζ
ιβ	ιβ.λγ νθ.ζ	νη	ιε.κδ.λγ.ιη	λε	ιη.ιζ.νβ.νθ	λα
ιγ	ιγ λϛ.μθ.ε	νη	ιϛ.κζ.κδ.νγ	λη	ιθ.κ.μη.λ	λϛ
ιδ	ιδ.λθ.λθ.γ	νθ	ιζ.λ ιϛ.λα	μα	κ.κγ.μδ.ϛ	μα
ιε	ιε.μβ.κθ.β	νθ	ιη.λγ.η ιβ	μδ	κα.κϛ.λθ.μζ	μϛ
ιϛ	ιϛ.με.ιθ.α	ν.*	ιθ.λε.νθ.νϛ	μζ	κβ.κθ.λε.λγ	νβ
ιζ	ιζ μη.θ.α	α	κ.λη.να.μγ	ν	κγ.λβ.λα.κε	νζ
ιη	ιη.ν.νθ.β	α	κα.μα.μγ.λγ	νγ	κδ.λε.κζ κβ	νϛ.β
ιθ	ιθ.νγ.μθ.γ	β	κβ.μδ.λε.κϛ	νε	κε.λη.κγ.κδ	η
κ	κ.νϛ.λθ.ε	γ	κγ.μζ.κζ. α	νθ	κϛ.μα.ιθ.λβ	ιγ
κα	κα.νθ.κθ.η	γ	κδ.ν.ιθ.κ	νβ.β	κζ.μδ.ιε.με	ιη
κβ	κγ.β.ιθ.ια	δ	κε.νγ.ια.κβ	ε	κη.μζ.ιβ.γ	κδ
γ	κδ.ε.θ.ιε	ε	κϛ.νϛ.γ.κζ	η	κθ.ν.η.κζ	κθ
κδ	κε.ζ.νθ.κ	ϛ	κζ.νη.νε.λε	ια	λ.νγ.δ.νϛ	λε
κε	κϛ.ι.μθ.κϛ	ζ	κθ.α.μζ.μϛ	ιε	λα.νϛ.α.λα	μ
κζ	κζ.ιγ.λθ.λγ	η	λ.δ.μ.α	ιη	λβ.νη.νη.ια	μϛ
κϛ	κη ιϛ.κθ.μα	θ	λα.ζ.λβ.ιθ	κα	λδ.α.νδ.νζ.	νβ
κη	κθ.ιθ.ιθ.ν	ι	λβ.ι.κδ.μ	κε	λε.δ.να.μθ	νζ
κθ	λ. κβ. ι.*	ιβ	λγ.ιγ.ιζ.ε	κη	λϛ.ζ μη.μϛ	νζ.γ
λ	λα κε.*.ιβ	ιγ	λδ.ιϛ.θ.λγ	λβ	λζ.ι.με.μθ	θ
λα	λβ.κζ.ν.κε	ιδ	λε.ιθ.β.ε	λε	λη.ιγ.μβ.νη	ιε
λβ	λγ.λ.μ.λθ	ιε	λϛ.κα.νδ.μ	λη	λθ.ιϛ.μ.ιγ	κ
λγ	λδ.λγ.λ.νδ	ιϛ	λζ.κδ.μζ.ιη	μβ	μ.ιθ.λζ.λγ	κϛ
λδ	λε.λϛ.κα.ι	ιζ	λη.κζ.μ.*	με	μα.κβ λδ.νθ	λβ
λε	λϛ.λθ.ια.κζ	ιθ	λθ.λ.λβ με	μθ	μβ.κε.λβ.λα	λη
λϛ	λζ.μβ.α.μϛ	κ	μ.λγ.κε.λδ	νγ	μγ.κη λ.θ	μδ
λζ	λη.μδ.νβ.ϛ	κβ	μα.λϛ.ιη.κζ	νζ	μδ.λα.κζ.νγ	ν

Table of Prime Tangents—*Continued.*

Deg.	*		a		β	
Min.	Tangent. Deg. Frths.	Difference. Min. Frths.	Tangent. Deg. Frths.	Difference. Min. Frths.	Tangent. Deg. Frths.	Difference. Min. Frths.
λη	*.λθ.μζ.μβ.κη	α.β.ν.κγ	α.μβ.λθ.ια.κδ	α.β.νγ.α	β.με.λδ.κε.μγ	α.β.νζ.νς
λθ	μ.ν.λβ.να	κδ	μγ.μβ.δ.κε	δ	μς.λζ.κγ.λθ	νη.γ
μ	μα.νγ.κγ.ιε	κς	μδ.μδ.νζ.κθ	η	μζ.μ.κα.μβ	η
μα	μβ.νς.γ.μα	κη	με.μζ.ν.λζ	ιβ	μη.μγ.ιθ.ν	ιε
μβ	μγ.νθ.δ.θ	κθ	μς.ν.μγ.μθ	ις	μθ.μς.ιη.ε	κα
μγ	με.α.νδ.λη	λα	μζ.νγ.λζ.ε	κ	ν.μθ.ις.κς	κζ
μδ	μς.δ.με.θ	λγ	μη.νς.λ.κε	κδ	να.νβ.ιδ.νγ	λγ
με	μζ.ζ.λε.μβ	λδ	μθ.νθ.κγ.μθ	κη	νβ.νε.ιγ.κς	λθ
μς	μη.ι.κς.ιζ	λς	να.β.ιζ.ιζ	λβ	νγ.νη.ιβ.ε	μς
μζ	μθ.ιγ.ις.νβ	λη	νβ.ε.ι.μθ	λς	νε.α.ι.να	νγ
μη	ν.ις.ζ.λ	μ	νγ.η.δ.κε	μ	νς.δ.θ.μδ	νθ
μθ	να.ιη.νη.ι	μα	νδ.ι.νη.ε	μδ	νζ.ζ.η.μγ	νθ.ς
ν	νβ.κα.μη.να	μγ	νε.ιγ.να.μθ	μθ	νη.ι.ζ.μθ	ιβ
να	νγ.κδ.λθ.λδ	με	νς.ις.με.λη	νγ	νθ.ιγ.ζ.α	ιθ
νβ	νδ.κζ.λ.ιθ	μζ	νζ.ιθ.λθ.λα	νζ	γ.*.ις.ς.κ	κε
νγ	νε.λ.κα.ς	ν	νη.κβ.λγ.κη	νδ.α	α.ιθ.ε.με	λβ
νδ	νς.λγ.ια.νς	νβ	νθ.κε.κζ.κθ	ς	β.κβ.ε.ιζ	λη
νε	νζ.λς.β.μη	νδ	β.*.κη.κα.λε	ι	γ.κε.δ.νε	ε
νς	νη.λη.νγ.μβ	νς	α.λα.ιε.με	ιε	δ.κη.δ.μ	νβ
νζ	νθ.μα.μδ.λη	νη	β.λδ.ι.*	ιθ	ε.λα.δ.λβ	νθ
νη	α.*.μδ.λε.λς	να.*	γ.λζ.δ.ιθ	κγ	ς.λδ.δ.λα	α.γ.*.ς
νθ	α.μζ.κε.λς	β	δ.λθ.νη.μβ	κη	ζ.λζ.δ.λζ	ιβ